Resource Status Assessment and Trends Methodology

California Legacy Project

The Resources Agency
July 3, 2002

Resource Assessment and Trends Methodology

California Legacy Project

Mary D. Nichols
Secretary
The Resources Agency

July 3, 2002

Michael Spear, Deputy Secretary for Resources, Land Conservation and Stewardship
Madelyn Glickfeld, Assistant Secretary for Resources, California Legacy Project

Lead Authors/ Editors:
Rainer Hoenicke – Environmental Program Manager, Resources Agency, California Legacy Project
Marc Hoshovsky – Senior Environmental Scientist, Department of Fish and Game, California Legacy Project

Draft Report Comments:
Several drafts of this report were reviewed by a work group comprised of resource conservation scientists. This workgroup included:

Roy Woodward, California Department of Parks and Recreation, Inventory, Monitoring, and Assessment Program
Eric Loft, Department of Fish and Game, Species and Natural Communities Assessment Program
Peggy O'Connell, U.S. Forest Service
Lisa Levien, Forest Inventory and Assessment, USFS
Pete Cafferata, California Department of Forestry and Fire Protection
Chris Fischer, Forest Resource Assessment Program, CDF
Elizabeth Gray, The Nature Conservancy
Susan Hill, U.S. Fish and Wildlife Service
Cathy Bleier, North Coast Watershed Assessment Program, Resources Agency
Barbara Washburn, Office of Environmental Health Hazard Assessment/EPIC
Greg Greenwood, Resources Agency
Jim Weigand, Bureau of Land Management
Molly Penberth, Department of Conservation

Additional comments were provided by:
Andrea Atkinson, United States Geological Survey and CALFED Science Program team member
Ed Pert, Department of Fish and Game, and
members of the Resources Agency executive team

Editorial and Production Assistance:
Dawn James, Resources Agency

Executive Summary

This report describes the methodology that the California Legacy Project will implement to report on the status and trends of California's natural resources. It builds on the June 2001 "Draft Conservation Audit Methodology" report to the Legislative Analyst's Office and revises reports on Key Data Needs and Resource Assessment Methodology Case Studies, which provide substantial information about existing assessment programs.

As a refresher to the previous report, this report provides a brief background on the California Legacy Project and existing natural resource assessment programs. The report introduces key concepts that are important for any assessment program to produce meaningful results for informing management decisions. These concepts are woven into a series of major steps that constitute the Legacy Project methodology itself. The report concludes with recognizing several key implementation issues involved in such an ambitious statewide approach.

The main goals of this methodology are to:

- Develop a robust, adaptive scientific framework for integrating and expanding existing assessment programs
- Strengthen partnerships with existing assessment programs
- Integrate the results from these various programs into a statewide picture of all five targets
- Identify existing gaps and seek funding for supporting and expanding existing state agency assessment programs.
- Improve the flow of information about resource status and trends among interested agencies and organizations

In developing this methodology, the Legacy Project desires to acknowledge and build upon the valuable progress already made, and still being made, by many agencies and organizations in assessing natural resources. Because resource assessment is an expensive undertaking, the Legacy Project needs to maintain and cultivate excellent working partnerships with these other assessment programs to be most cost-effective. These partnerships depend on all parties working together on common goals that provide sufficient benefit to each. Legacy's role in implementing this methodology is to provide a catalyst for convening organizations, identifying common goals and needs, and integrating results from a variety of different sources.

This dependence on partnerships with other agencies and organizations implies that this methodology can only be fully implemented if it makes sense to our partners and provides added value to their current efforts. The Legacy Project will actively engage these other agencies during the coming year to discuss and improve this methodology so that it best meets the interests of all partners. Successful implementation will depend, then, on the ease of reaching agreements, of finding sufficient funds, and in securing sufficient administrative and technical support.

The major steps of the methodology are to work collaboratively with conservation partners to:

- Develop quantifiable resource conservation goals, and benchmarks, where appropriate
- Identify high-priority appropriate management and assessment questions for use with indicators
- Develop and use conceptual models and essential landscape and ecosystem attributes to help understand complex systems and to select appropriate indicators
- Identify current data collection efforts
- Assess and collaborate on priority gaps in current monitoring efforts
- Report on and provide access to assessment data and analysis products
- Develop regular workplans that help enhance current assessment programs
- Seek funding and additional partners to fill data gaps

These steps are not strictly in a sequential order and results are likely to be incremental in nature.

TABLE OF CONTENTS

I. Purpose of the Report

This report builds on previous reports issued by the California Legacy Project and describes the methodology that the California Legacy Project will implement to report on the status and trends of California's conservation resources. The methodology represents the blueprint for future Resource Status Assessment and Trends reports[1]. It provides background on the Legacy Project and existing resource assessment programs conducted by its conservation partners. The report introduces key concepts that are important for any assessment program to inform management decisions. These concepts are woven into a series of major steps that constitute the Legacy Project methodology itself. The report concludes with recognizing several important implementation issues that need to be considered in such an ambitious statewide approach.

The Legacy Project is structured to build upon the valuable progress already made, and still being made, by many agencies and organizations in assessing resource condition for geographically and thematically focused areas of the state. We recognize the substantial groundwork that state and federal agencies, as well as private conservation organizations have laid in the last decade in forging and maintaining links between monitoring information and policy development. A few of the most notable conservation management efforts at the landscape and ecosystem level are the Northwest Forest Plan, the Sierra Framework, the CALFED Science Program, and the Natural Community Conservation Planning Program. They have been largely successful in tightly connecting monitoring and assessment components with decision-making processes and policy improvements. We will apply as much as possible the lessons and tools these programs provide for thematically or geographically focused areas to the broader goals of the Legacy Project.

Because resource assessment is an expensive undertaking, the Legacy Project needs to maintain and cultivate excellent working partnerships with other assessment programs to be most cost-effective. These partnerships depend on all parties working together on common goals that provide sufficient benefits to each. The Legacy Project's role in implementing the methodology described in this report is to be a catalyst for convening organizations, identifying common goals and needs, and integrating results from a variety of different sources.

---

[1] As this methodology was developed at the same time as the first Resource Status Assessment and Trends Report, the approach outlined herein will be reflected beginning with the 2003 resource status and trends assessment. The first report for 2002 will include indicators that we think are current, based on acceptable data and available for regional or statewide mapping.

The first report should also include some major work by our departments (e.g. The Biodiversity Atlas by the Department of Fish and Game; the Forest Resources Assessment Report by the Department of Forestry and Fire Protection). However, both are still in the final stages of preparation and are not ready to be included in the first resource status and trends report.

Each successive report will make steps towards implementing the methodology described in this document. There will be work done to coordinate the timing of this report with key work done by our departments and other agencies so that they can be used as the basic building blocks for the report.

This dependence on partnerships with other agencies and organizations implies that this methodology can only be fully implemented if it makes sense to our partners and provides added value to their current efforts. The Legacy Project will continue to actively engage its conservation partners during the coming years to implement and improve this methodology so that it best meets the interests of everyone. Successful implementation will depend, then, on the ease of reaching agreements, of finding sufficient funds, and in securing sufficient administrative and technical support. When funding cuts or increasing legal mandates do not allow our partners the discretion to put their considerable expertise to the objectives of this project, their contributions toward full implementation will be slowed down. When the budget for the Legacy Project itself is reduced, our ability to develop a conservation investment strategy with our departments based on rigorous health and condition assessments will be affected.

This Resource Status and Trends Methodology is not intended to replace existing monitoring and study designs for smaller geographic areas or specific natural resources, such as monitoring the success of a specific stream restoration project, or the recovery of an endangered species. The basic principles of this framework are applicable at any geographic scale or conservation focus and can be applied in any decision-making context.

II. Context of Report

California Legacy Project Overview

Public agencies and private organizations are making substantial investments in natural resource conservation throughout the state. These investments are both in specific sites, such as the establishment of protected areas, and in managing resources across the landscape, such as in maintaining forest health or maintaining biodiversity in State Parks and wildlife reserves. One of the key questions related to these investments is: “How can we insure that the outcomes of conservation investment we make today can be sustained into the long-range future?”

The Legacy Project has developed the following goals to address this question, as well as the broader question of where to make state conservation investments:

- Develop a strategic context for statewide conservation investments.
- Build on local conservation planning efforts.
- Continually improve the process and basis for decision-making.
- Develop a method to assess the health and condition of resources throughout the state.
- Link the sources of health and condition problems to potential kinds of investments to restore and protect the long-term health of resources.
- Consider maintaining or restoring the health and condition of resources over time in the context of priority conservation investments.
- Coordinate conservation actions among partners.
- Include proposed actions designed to maintain or restore the health and condition of priority ecosystems and working landscapes over time as a major category of conservation investments for California.

Goals of Methodology

This methodology builds on the June 2001 "Draft Conservation Audit Methodology" report to the Legislative Analyst's Office, as well as the reports on key data needs and resource assessment methodology case studies (Resources Agency, 2001a, b,c), which provide substantial information about existing assessment programs. These various programs individually address only parts of Project's five general conservation targets: (1) terrestrial biodiversity; (2) aquatic biodiversity and watershed values; (3) working landscapes; (4) recreational lands; and (5) urban open space.

The main goals of this methodology are to:

- Develop a robust, adaptive scientific framework for integrating and expanding existing assessment programs
- Strengthen partnerships with existing assessment programs
- Integrate the results from these various programs into a statewide picture of all five targets
- Identify existing gaps and seek funding for supporting and expanding existing state agency assessment programs
- Improve the flow of information about resource status and trends among interested agencies and organizations

Key Concepts for a Statewide Methodology

The concepts and terms described below are derived from a series of recent scientific assessment framework documents, all of which are built on the principle of adaptive management. The Legacy Project's resource assessment methodology follows these science-based and widely accepted frameworks, summarized in **Appendix A**.

Goals and objectives, also known as ***benchmarks*** *or* ***targets*** for "acceptable resource health and condition" are important starting points for assessments. The primary reason for assessing resources is to compare their existing and projected conditions with desired conditions so that informed actions can be taken to improve or maintain the "health" of ecosystems and working landscapes. For example, if citizens desire high water quality, but they do not have adequate water quality everywhere it is desired, then conservation investments can be made to improve water quality. Goal statements are often associated with the concept of sustainability (for a discussion of required sustainable system conditions, see Robert et al. 1996). "Healthy" ecosystems are usually described as maintaining biodiversity, being stable over time, and resilient to change. "Healthy" working landscapes can be defined as being able to maintain the flow of material inputs (e.g., water, nutrients) and commodity outputs without violating basic ecological and sustainability principles. "Acceptable" conditions are subjective expressions of goals best informed by scientific information, such as historical resource data and established effects threshold levels. Many different resource conservation projects already have project-specific goals, or organization-specific goals, and in many cases, goals are reflected in legal mandates.

Indicators are measurable characteristics representing landscape and ecosystem condition and factors influencing them. They convey complex information in a concise, easily understood format and have significance beyond that directly associated with the individual measures or monitoring data from which they are derived. Indicators often serve as measurable "endpoints" for comparisons to goals and objectives. They usually are comprised of multiple individual parameters. A recent example of their use in California is the Environmental Protection Indicators of California (EPIC) report (Office of Environmental Health Hazard Protection, 2002).

Indicators are often categorized into three different types.
Condition indicators describe the current condition of resources, such as acres of a certain type of habitat, trace elements in water, or floodplain complexity.
Stressor indicators describe factors that lead to a change in condition. For example, urban expansion is a stressor that may decrease the acres of wildlife habitat near urban areas.
Outcome indicators describe the performance of management or investment actions, such acquisition or increased private-land stewardship funding. Outcomes indicators represent measures of particular actions to improve the health and condition of resources. We purposefully differentiate programmatic outcomes from those that others define as the ultimately targeted 'environmental outcomes'. Environmental outcomes ultimately express themselves, sometimes with considerable time lags, in improved condition.

Indicators are most useful, and relate best to goals, when they are described as part of a conceptual model. ***Conceptual models*** are important for several reasons. They are tools to organize thought processes and to synthesize the current knowledge about a particular resource and the factors influencing it. They are effective communication tools for summarizing current understanding and for predicting possible outcomes of management or investment choices. For example, acreage of riparian habitat is often related to the population size and health of songbirds. If the goal is to improve songbird populations, but measuring the populations directly is too expensive, then a riparian model can illustrate how riparian habitat may be a good indicator for songbird populations. It may also illustrate how other important factors, such as flood management efforts or upstream land use, may strongly influence songbird populations. Furthermore, they serve in project planning by identifying critical data gaps and defining the scope of assessment improvements. Conceptual models link condition, stressor, and outcome indicators and can communicate what kinds of management actions or investment choices might be most effective. Examples of conceptual models of various complexity and purposes are depicted in Figures A1-A3.

For a statewide assessment striving to assess a variety of resources, or ***essential landscape attributes***, can be useful to ensure that a broad array of indicators is included in the assessment. Examples include land cover, ecosystems, species, disturbance regimes, and water chemistry. A list of attributes, modified from an EPA Science Advisory Board Report (EPA-SAB, 2002) is contained in Table 1. It essentially represents a menu from which to choose those attributes that are appropriate for the resource assessment, regardless of the specific objectives for which individual monitoring parameters were collected. For example, salinity levels at a water diversion pump may be measured for the purpose of managing the timing of water releases from

upstream reservoirs, but they may also serve to evaluate the extent of estuarine habitat types. Selecting at least several indicators for each attribute helps ensure that no key part of the landscape is overlooked. Previous assessments have focused, for example, on physical or chemical characteristics alone without considering biological components. This broader inclusion can minimize erroneous conclusions drawn from only part of the landscape.

Measures, or data, are the specific resource inventory or monitoring parameters, such as stream flow rates, species occurrences, number of vernal pools, occurrence and size of artichoke crop lands, etc., that are measured in the field and aggregated into one or more indicators, such as croplands of statewide significance, species diversity, or acres of wetlands under protection. Often, individual measures only become meaningful when placed in context with many other measures.

Table 1. Essential Landscape and Ecosystem Attributes

- **Landscape Condition**
  - Extent of habitat types
  - Vegetation cover
  - Land use
  - Landscape pattern and structure
- **Biotic Condition**
  - Ecosystems and Communities
    - Community extent
    - Community composition
    - Trophic structure
    - Community dynamics
    - Physical structure
  - Species and Populations
    - Population size
    - Genetic diversity
    - Population structure
    - Population dynamics
    - Habitat suitability
  - Organism Condition
    - Physiological status
    - Signs and symptoms of disease
- **Ecological and Production Land Processes**
  - Energy flow
    - Net primary production
    - Growth efficiency
  - Material flow
    - Organic carbon cycling
    - N and P cycling
    - Other nutrient cycling
- **Hydrology and Geomorphology**
  - Surface and groundwater flows
    - Pattern of surface/groundwater flows
    - Hydrodynamics
    - Salinity patterns
    - Water storage
  - Sediment and material transport
    - Sediment supply/movement
    - Particle size distribution patterns
  - Dynamic structural characteristics
    - Channel morphology and complexity
    - Distribution and extent of connected floodplain
    - Shoreline characteristics
- **Chemical and Physical Characteristics**
  (Water, Air, Soil, Sediment)
  - Nutrient Concentrations
    - Nitrogen
    - Phosphorus
    - Others
  - Natural Trace Substances
    - Metals
    - Other Natural Organic and Inorganic Trace Substances
  - Other Chemical Parameters
    - pH
    - Dissolved Oxygen
    - Salinity
    - Organic Matter
    - Other
  - Physical Parameters
    - Temperature
    - Soil/sediment characteristics
    - Turbidity
    - Other
- **Natural Disturbance Regimes**
  - Frequency
  - Intensity
  - Extent
  - Duration

Most of these essential attributes can be tracked by condition, stressor, and outcome indicators. Table 2 shows examples of these indicators, grouped by attribute.

Table 2. Select Essential Landscape and Ecological Attributes and Corresponding Examples of Condition, Stressor, and Outcome Indicators

LANDSCAPE CONDITION			
Attributes	*Example Condition Indicators*	*Example Stressor Indicators*	*Example Outcome Indicators*
Vegetation cover	Number of vegetation types	Number and extent of catastrophic fires; ozone exceedances; Nox/SOx emissions; biological invasions	Number and extent of controlled burns;
Landscape composition	Number of habitat types; presence of native plant communities, measures of topography; slope	Fragmentation rates; biological invasions;	Number of habitat types under conservation; area of invasive species eradicated
BIOTIC COMPOSITION			
Ecosystems and communities	Extent of native communities vertical stand structure; tree canopy height; large woody debris in streams;	Habitat conversion rates; biological invasions; exposure to pollutants above threshold levels; alteration of hydrologic regimes	Number of native communities protected; reduction in manufacture and certification of bioaccumulative synthetic substances
Species and populations	Population age structure; habitat attributes important to focal species; birth and death rates	Habitat conversion rates; biological invasions; exposure to pollutants above threshold levels; alteration of hydrologic regimes	Number of species recovery plans; miles of streams restored;
HYDROLOGY AND GEOMORPHOLOGY			
Surface and groundwater flows	Flow magnitude and variability; watershed "yield"; groundwater accretion; net recharge or withdrawals	Number of water diversions per stream reach; number and location of dams; amount of impervious surface; number of extraction wells	Number of anadromous fish migration barriers removed; miles of dry reaches restored to minimum flows;
Sediment and material transport	Sediment deposition; sediment residence time and flushing; degree of embeddedness	Erosion rates from agricultural fields and timber harvest areas; reduced dry-season flow rates; increased flood peaks; degree of stream bed scour	Number of watershed stewardship programs with sustainable funding sources and performance measures in place;

III. Resource Status and Trends Methodology

The Legacy Project's methodology is based on the key concepts discussed above. The success of implementing this approach depends heavily on productive partnerships with other existing assessment programs, both with state government and other conservation partners.

The methodology proposed for the Legacy Project involves the following steps:

- Develop quantifiable resource conservation goals and benchmarks, where appropriate, in collaboration with conservation partners
- Develop and use, in coordination with specialists, conceptual models that help understand how complex systems work, and that can be used to select the full range of indicators required to prioritize conservation investments
- Use essential landscape and ecosystem attributes listed to select applicable condition, stressor, and outcome indicators, in coordination with conservation partners
- Identify current data collection efforts to aggregate individual measures into indicators
- Assess gaps in current monitoring efforts and develop efficient ways to fill those gaps by developing new partnerships and maximizing existing and new funding sources
- Develop an information exchange and distribution system, effectively communicate status and trends, and provide decision support
- Champion the adaptive management process and share annual work plans that describe which data will be aggregated into indicators and categories of essential landscape/ecosystem attributes for reporting purposes, which gaps will be filled each year, and what kinds of program adjustments need to be made based on lessons learned.

Selection of Goals and Investment Target Benchmarks

As a starting point for evaluating resource health and condition and trends, increasingly specific assessment questions can be hierarchically arranged. These questions can then be organized according to which essential landscape and ecological attributes (Table 1) they correspond with. The "top-down" approach to information compilation based on the science framework described in Appendix A is being complemented by a "bottom-up" assessment of resource stewardship and management goals derived from the mandates of the key conservation partners in government, and the private non-profit sector. **Appendix B** contains a list of general goals that will require discussion and confirmation by our conservation partners.

During the latter part of 2002 and in early 2003, the Legacy Project will continue to gather information on important conservation goals and targets as it holds regional workshops throughout the state. Conservation partners in these regions will be able to identify which types of indicators have been successfully applied to describe landscape, habitat, and species condition and stress factors acting on their health. The organizing tools outlined above help in selecting available data and identifying data gaps in a more targeted fashion than was done initially in the Evaluation of Existing Data Sets

(Resources Agency 2001b) and Resource Assessment Methodology Case Studies (Resources Agency, 2001c). It is recommended that Resource Agency Boards, Departments, Conservancies, and Commissions (BDCCs) and other conservation partners and stakeholders support the development of quantifiable benchmark targets for adequate health and condition. Without such benchmark targets, it will be difficult to assess which ecosystems are functioning and which are in trouble. In fact, adaptive management is impossible without them.

If the decision to proceed with development of benchmark targets for adequate health and condition is made, and if funding resources are available, the Legacy Project staff would consult with its stakeholder and management advisory committees to establish a statewide scientific panel to recommend specific benchmark targets for different types of natural ecosystems and working landscapes. The scientific recommendations would be presented to the Secretary and to our advisory committees for approval of the benchmark targets for conservation, since such targets are based on as much societal and cultural values as they are informed by science.

Selection of Appropriate Environmental and Program Management and Assessment Questions for Health and Condition Indicators

The project has worked with the National Center for Ecological Analysis and Synthesis to develop a conservation priorities methodology. The first test of that methodology was the development of test conservation investment priority criteria by experts. Since then, a simpler method has been developed to elicit conservation priority criteria from regional and statewide stakeholders. These criteria are being developed for each bioregion as local and regional stakeholders provide feedback at a series of conservation workshops throughout the state in 2002 and 2003. The results of these workshops will be reported to the advisory committees, Resource Agency BDCCs and then to the Governor and Legislature.

Concurrently, Legacy Staff has been working with a “Monitoring Committee” of state, federal and nonprofit scientists to assemble the appropriate management and assessment questions each particular agency needs to ask based on its legal mandates. More work needs to be done with the monitoring committee, and then with other representatives of agencies to review and edit those questions. While that work is proceeding, the initial criteria and current assessment questions can be used, in collaboration with our conservation partners to determine what kinds of indicators of resource condition, stressors, and causes of stress might be suitable for a state as diverse as California. Selection of performance and outcome indicators capable of tracking success will also be part of this step. Geo-spatial data depicting selected indicators will be used for “Health and Condition” updates, including a description of risks to resources and resource investments.

Identification and Prioritization of Significant Data Gaps

For some regions of the state, data on resource condition or risks to a resource may not be available or of insufficient resolution and detail to permit conservation investments prior to narrowing these data gaps. For example, prior to knowing the risks that land use practices in the upper parts of a watershed may pose to conservation targets in the lower parts, it may not be wise to allocate tax dollars to acquisition or restoration

activities that may have an unknown probability of succeeding. A number of potential indicators may in theory represent ideal surrogates for describing conditions or quantifying stresses on natural resources, but no quantitative statements can yet be made due to insufficient data. By identifying data gaps common to multiple conservation partners, funds and staff resources can be prioritized in a collaborative manner collect the appropriate data to make a particular indicator quantifiable and useful.

Seek Funding and Additional Partners to Fill Data Gaps

One of the beneficial roles the Legacy Project can play is as facilitator and catalyst of fundraising efforts to support resource assessment efforts by our conservation partners and to leverage and consolidate resources for monitoring from a wide variety of sources, including foundations and federal programs. When project funding allows, the Legacy Project can provide seed funds and seek matching funds to fill important data gaps. The project can also host technical groups that want to design a data layer to be added to fill a gap. The project has also acted to help strengthen chances of funding success of individual grant applications by our conservation partners to funding entities by demonstrating consolidated and coordinated approaches to filling data gaps that they have worked with Legacy Project staff to identify and prioritize.

The Building Blocks for the Resource Assessment

The summary grouping of monitoring and assessment goals and corresponding data collection activities by some of our conservation partners in Appendix B demonstrates that their activities depend on the stewardship focus and mandates of each agency or consortium. Some of their efforts are focused on regional issues, others on a limited number of resource types, such as biodiversity, agricultural lands, park and recreation lands, air quality, or water quality and water use. Below, we describe the major building blocks of a statewide resource assessment and how the Legacy Project is intending to systematically assemble these blocks into an assessment that will cover as much of the state as possible at the required level of resolution in all five conservation categories. We will use the information generated by individual assessment programs to identify

- which areas of the state still have relatively intact ecosystem processes and functions, and which of these ecosystems are considered at risk from projected human activities and land use practices,
- where working landscapes of statewide and local significance currently are and which ones require state attention to keep them in working condition, and
- what kinds of recreational and open space areas exist in which parts of the state in relationship to current and anticipated user needs.

The following major programs address one or more of these issues at various levels of resolution and geography. Some are statewide, others focus on parts of the state only.

1. **The Fire and Resource and Assessment Program (FRAP**) is within the California Department of Forestry and Fire Protection and conducts periodic assessment of Forest and Rangeland Resources. The 2002 Forest and Range Assessment, scheduled to be issued later this year, will cover topics including supply and availability of forest and range resources, the benefits and costs of resource management, opportunities for improvement, and relevant federal,

state, and local policies and programs. The FRAP assessments are conducted at a fairly coarse scale, suitable for general conclusions about changes in the extent and quality of key resource attributes Indicators include vegetation cover, (e.g., hardwood forests, oak savannahs, conifer forests, grasslands, scrublands), degree of fragmentation, extent and quantity of wildlife habitats, quantity and condition of key habitats of concern (old growth, hardwood, riparian), structural condition of wildlife habitat, habitat loss and land use trends, species diversity and threats to biological diversity, production of ecological services, and natural and human-caused ecosystem disturbances, including fires and pest conditions. The assessment also includes economic indicators, such as demand and supply analysis for forest resources, employment level and economic structures, and others. Indicators of social conditions are also included, such as population growth trends, demographic profiles and impacts, and rural community structure including recreational opportunities, level of government services, level of life style amenities, ownership patterns, and regulatory trends. The FRAP assessments are possibly the geographically most extensive information compilation efforts that are related to conservation resources and associated economic and social values in California and can serve as the basic layer of coarse-scale landscape attributes upon which more detailed and accurate data can be placed for additional analysis. The scale appropriate for analysis of FRAP data varies from 5 acres to county-size. Certain essential landscape attributes can be directly derived from the FRAP efforts, while others need to be augmented with finer-resolution data from other assessment activities.

2. **The Natural Communities Conservation Planning Program (NCCP)** is managed by the Department of Fish and Game and includes extensive partnerships with federal and local government agencies as well as private organizations and landowners. Monitoring and assessment components are built into the implementation of conservation plans. This includes evaluation of the regional connectivity of reserves and their capacity to maintain viable populations of fragmentation-sensitive species, focusing on large carnivores. Data are developed at significantly finer scales than those compiled and analyzed by FRAP but are geographically limited usually to parts of counties. They are most prevalent in those areas of the state with high human population growth rates, land use conflicts, and a large number of species at risk, where limited habitat conservation options and the application of the federal and state endangered species statutes provide appropriate incentives for local government, land owners and conservation advocates to participate.

3. **The California Natural Diversity Data Base** is a program established in California in 1979 as a component of The Nature Conservancy's (TNC) International Heritage Network. It is a partnership between TNC's recently separated scientific group, NatureServe and the Department of Fish and Game. The data base is set up to track site occurrences of numerous sensitive plant and animal species and on important natural communities throughout the state. The database provides the most current information on the state's most imperiled elements of natural diversity and includes information at a site-specific scale. The CNDDB allows individuals to submit data where they are studying species and

habitats of concern. While the Department does a considerable amount of quality control on the data, it cannot be considered a representative survey of the of species distribution in state as a whole

4. **The North Coast Watershed Assessment Program** is a multi-agency effort administered by the Resources Agency. Its goal is to assess biophysical conditions in six north coast watersheds, with particular emphasis on determining "limiting factors" to the survival and reproductive success of anadromous fish. This includes evaluation of land and water use changes over time within the targeted watersheds. Assessment components while limited to North Coast watersheds, is at a finer scale than FRAP landscape assessments. The program evaluates several essential landscape attributes, such as landslides, sediment storage and movement, riparian corridor condition, fish habitat extent and condition, and physical and chemical water quality parameters.

5. **The Statewide Water Quality Assessment Program** is administered by the State Water Resources Control Board and its nine Regional Boards and focuses on assessing the condition of the state's waters. Data collection began in 2001 in selected watersheds in each of state's nine regions with emphasis on site-specific locations, aereal extent and trend evaluations. The sampling design is still somewhat in flux, although a rotating watershed sampling approach has already been implemented. The program is beginning to provide data relevant to the Legacy Project in terms of chemical and physical stressors impacting aquatic life, as well as riparian habitat condition and hydro-geomorphic information useful for determining the degree to which watershed processes may be intact or impaired.

6. **The CALFED Science Program** is a component of a multi-agency consortium established to resolve decades of competing demands on California's water. The CALFED Science Program is providing critical information for several purposes related to water use, storage and conveyance improvements, ecosystem and watershed restoration, and drinking water quality. The program's data collection and monitoring activities cover more than half of the state from the project level to large-scale river basin assessments.

7. **The Environmental Protection Indicators for California (EPIC) program,** is a partnership effort between the Resources Agency and the California Environmental Protection Agency and is administered by the Office of Environmental Health Hazard Protection at CALEPA. It is tasked with developing environmental indicators designed to evaluate the effectiveness of the state's efforts directed at environmental protection. It is a multi-agency framework for identifying and selecting environmental issues that are important for the state to track over time and for identifying and selecting indicators representing important environmental issues, among them health and condition of natural resources. Its scope is statewide and includes initial indicators of ecosystem health. The program was not intended to develop a landscape-level data system for resources assessment and monitoring, although it is evaluating very similar data as the Legacy Project. However, EPIC is not broken down spatially into eco-regions, riverbasins or other geographic units for analysis. The program is

designed to support the various boards and departments within the auspices of CalEPA and therefore covers a much broader range of interpretations of environmental indicator than may be relevant to the Legacy Project. However, the Legacy Project and OEHHA are collaborating on developing GIS maps from some of the key stressors that affect natural and working landscapes.

8. **The Natural Resources Inventory, Monitoring, and Assessment Program** of the Department of Parks and Recreation focuses on identification of the condition of sensitive species, selected indicator species, key processes in environmental complexes, and identification of threats. The program was established in 2000 and focuses on monitoring health and condition in and around state park units. Data collected under this program will be useful for assessing conditions of natural resources in these areas, but will be spatially restricted.

9. **The Species and Natural Communities Monitoring and Assessment Program** was initiated in 2001 by the Department of Fish and Game. Its main goals are to inventory, monitor, and assess the distribution and abundance of priority species, habitats, and natural communities. The program is intended to bring many of the Department's data collection activities under one umbrella and refocus many of its existing efforts in the collection, analysis, and use of data on native fish, wildlife, plants, and communities. This new program promises to integrate biodiversity-related parameters into a statewide assessment using a very similar scientific framework as the Legacy Project. It is too early to tell how we can facilitate the development of statewide data layers in collaboration with the Department.

Parallel to, and often in collaboration with, state-sponsored resource assessment programs, numerous federal, local, and private monitoring efforts exist that will provide useful data to the Legacy Project for data aggregation and selection of appropriate indicators. Some of these have been summarized in the Resource Assessment Methodology Case Studies (Resources Agency, 2001 c) and will not be mentioned here.

IV. Implementation Issues

The manner in which the California Legacy Project is structured dictates to some extent how the methodology can and cannot be implemented. The Legacy Project is designed to provide and apply the nails and glue but not the building blocks with which to assemble a coherent and comprehensive statewide picture of conservation resources. We therefore depend to a large degree on our partners. Communication and facilitation of scientific and policy decisions are of great importance to achieve agreement on a list of condition, stressor, and outcome indicators. Only to the degree that individual boards, departments, commissions, and conservancies are capable of meeting their basic mandates, will department directors be able to consider and support broader, overarching, and cross-jurisdictional issues. The methodology described in this report therefore represents a vision and roadmap that can only succeed in collaboration with our conservation partners.

Data in specific subject areas have often been collected faster than they can be analyzed using sophisticated statistical procedures or simple numerical models. It is therefore important to recognize that sufficient resources need to be allocated to analytical processes following data collection that allow managers and policy-makers to determine if their decisions are likely to result in environmental benefits to society that outweigh their costs to the taxpayer. This fact has implicitly been acknowledged by establishing the Legacy Project, since one of its key tasks is to integrate and analyze a variety of disparate existing data sets and work with conservation partners to catalyze the production of analytic maps and other products that can be used for decision-making purposes.

We need to recognize that the level of analysis required for strategic investment decisions will not be clearly defined until we have assembled an agreed-upon list of target indicators suitable for supporting strategic, statewide investment decisions. Also, it is important to note that interpreting indicator values is not a trivial task, especially in circumstances where clear threshold levels or quantitative goals are not available. In those cases, agreement needs to be established first as to meaningful reference conditions that could be used to normalize results for aggregation into indicators or various levels of essential attribute categories. Reference condition for each resource (e.g., agricultural landscape, urban open space, habitat), ecoregion, or ecological unit should be established so that the same characteristics from different regions may be compared. Often, reference conditions are best derived from historical records. A successful example of using historical data to assemble a picture of what might be feasible to restore and what kinds of benchmark targets might be realistic is the Baylands Ecosystem Habitat Goals project (U.S.EPA, San Francisco Bay Regional Water Quality Control Board, 1999).

Information Exchange, Communication, and Decision-Support Tools

The Legacy Project is scheduled to issue periodic Resource Status Assessment and Trends reports that can meet the needs of resource managers, decision-makers, and the public. Frequency of reporting will depend on several factors, among them how rapidly conditions are expected to change, and the costs of data collection, compilation and analysis. For the science framework components, as outlined in Appendix A to be implemented successfully, efficient mechanisms for data compilation and aggregation will have to be developed.

The Bay-Delta Science Consortium issued a draft concept paper for a monitoring and modeling, data aggregation, storage, retrieval, integration and distribution system that provides a suite of technological solutions for various groups interested in sharing data and information. The Legacy Project will evaluate this system for potential adaptation statewide and collaborate with the Bay-Delta Science Consortium in its implementation.

As an interim step and pursuant to its legislative charge, the Legacy Project has begun to assemble digital maps, which will be distributed via a web based mapping application. The web site for this purpose (“Digital Conservation Atlas”) is currently being designed in consultation and coordination with our conservation partners. Figure 1 shows the concept behind the atlas, which will contain analytical maps and associated databases related to the conservation assessment questions and is envisioned to provide data and decision support tools for conservation decisions at the state, bioregional and landscape levels.

This atlas will also eventually form the foundation for communicating results of investment choices to the public, ranging from fee acquisition of land, conservation and major trail and other access easements, direct action and grants for restoration, and landscape level private stewardship investments via GIS maps. The California Digital Conservation Atlas will work to develop maps and information about maps available on other public digital atlases about resources and conservation. If funding resources allow, the California Digital Conservation Atlas will evolve into a primary tool for our departments, boards, commissions and conservancies to use as a tool to support their own conservation investment decisions. It could also serve users to forecast and model conservation outcomes by selecting and optimizing decisions based on a large number of criteria. Figure 1 shows the envisioned functions and purposes of the atlas.

Resource Status and Trends Assessment Users

The series of resource status assessment and trends updates to be issued by the Legacy Project will serve three main audiences: (1) Resource managers in the various boards, departments, conservancies, commissions and offices of the Resources Agency and CalEPA, as well as our federal, local, and private conservation partners; (2) policy makers and decision makers, including elected and appointed officials; and (3) the interested public, including stakeholders impacted by conservation, as well as stakeholders that advocate or implement conservation efforts. Each audience has different levels of interest and expertise. The reports can be organized at levels of information aggregation appropriate for each audience, either at the full spectrum of individual condition, stress, and outcome indicators, or subcategories and categories of essential landscape and ecosystem attributes.

The updates will also represent a mechanism for documenting and organizing in a hierarchical fashion the list of attributes and indicators for the assessment, the rationale behind indicator selection, the rationale for omitting certain attributes or indicators, and the considerations behind collapsing indicators into subcategories and categories of essential attributes, and major stress or risk factors. As the US EPA Science Advisory Panels have pointed out, effective reporting requires policy judgments and scientific understanding to determine WHAT to report, and it requires communications expertise to determine HOW to report it.

Figure 1. Digital Conservation Atlas Concept

V. References

EPA Science Advisory Board. 1995. SAB Review of Environmental Monitoring and Assessment Program Landscape Component. EPA-SAB-EPEC-LTR-95-002

EPA Science Advisory Board.1997. Development of Phase II of the Index of Watershed Indicators. EPA-SAB-ADV-97-003

EPA Science Advisory Board.2000. Toward Integrated Environmental Decision-making.

EPA Science Advisory Board. 2002. A Framework for Assessing and Reporting on Ecological Condition. Ecological Processes and Effects Committee, Ecological Reporting Panel.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared ;by the San Francisco Bay Area Wetlands Ecosystem Goal Project. U.S. Environmental Protection Agency, San Francisco, CA, and San Francisco bay Regional Water Quality control Board, Oakland, CA.

Healey, M.C. and T.M. Hennessey. 1994. The Utilization of Scientific Information in the Management of Estuarine Ecosystems. Ocean and Coastal Management 23: 167-191.

Hoenicke, R. , J.D. Davis, A. Gunther, T.E. Mumley, K. Abu-Saba and K. Taberski in press. Effective Application of Monitoring Information: The Case of San Francisco Bay. Environmental Monitoring and Assessment.

The Heinz Center. 1999. Designing a Report on the State of the Nation's Ecosystems: Selected Measurements for Croplands, Forests, and Coasts and Oceans. The H. John Heinz III Center, Washington, D.C. www.us-ecosystems.org

Ludwig, D., R. Hilborn, and C. Walters.1993. Uncertainty, Resource Exploitation, and Conservation: Lessons from History. Science 260: 17-36

National Research Council (NRC). 1990a. Managing Troubled Waters, Washington, D.C. National Academy Press.

National Research Council (NRC). 1990b. Monitoring Southern California's Coastal Waters: A Case Study. Washington, D.C. National Academy Press.

National Research Council (NRC). 1993. Managing Wastewater in Coastal Urban Areas. Washington, D.C. National Academy Press.

Office of Environmental Health Hazard Protection. 2002. Environmental Protection Indicators for California. Sacramento, CA. www.oehha.ca.gov

Resources Agency. 2001a. Draft Conservation Audit Methodology.

Resources Agency. 2001b. Key Data Needs, Evaluation of Existing Data Sets, and Identification of Important Data Gaps.

Resources Agency. 2001c. Resource Assessment Methodology Case Studies

Robert, K.-H., Holmberg, J. and Eriksson, K.-E. 1996. Socio-ecological principles for a sustainable society. In: Getting Down to Earth – Practical Applications for Ecological Economics. R. Costanza, ed. Island Press, Washington, D.C.

Swanson, F.J. and S. Green. 1999. Perspectives on Scientists and Science in Bioregional Assessments. In: Bioregional Assessments. K.N. Johnson, F.Swanson, M. Herring, and S. Greene, editors. Island Press, Washington, D.C.

APPENDIX A

The Science Framework for Resource Monitoring and Assessment in the Context of Adaptive Management

During the last few decades, the need for improved management of environmental resources has become increasingly apparent. The U.S. Environmental Protection Agency and later the U.S. Forest Service became driving forces behind strong feedback loops between environmental management decisions and scientific information that could inform each other. In late 1980s and early 1990s, the National Research Council (NRC) conducted in-depth reviews of environmental management and monitoring programs and recommended improvements summarized in a series of publications (NRC, 1990a,b, 1993). Since then, numerous attempts have been made to implement the recommendations contained in the NRC reports. With regard to broad-scale national as well as regional assessments on a smaller scale, many of these attempts have resulted in major improvements in management responses to newly developed scientific information (for a review, see Hoenicke *et al.* in press). These improvements are based on a process known as "adaptive management", in which monitoring and special study results are used to guide management decisions and to refine the inventory, monitoring, or assessment program. (EPA Science Advisory Board, 2000; Healey and Hennessey, 1994; Ludwig *et al.*, 1993). The establishment of the California Legacy Project, in applying the adaptive management process in strategic statewide conservation decisions, reflects the evolution of this process.

The emerging national consensus on assessing and reporting on environmental and resource conditions for decision support has been described in numerous reports, most notably in the National Research Council publications listed above and the U.S. Environmental Protection Agency's Science Advisory Board reports (SAB 1995,1997, 2000, 2002).

The four most consistently mentioned elements of environmental assessments are:

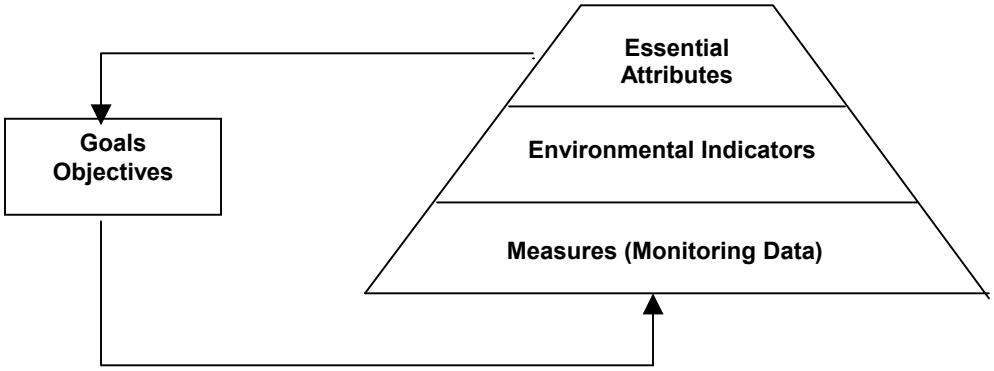
- setting goals and objectives;
- development of conceptual models;
- development of landscape and ecosystem attributes and indicators; and
- compiling or generating individual measures or monitoring data that can be aggregated into essential indicators and attributes. These measures may range from those pertaining to management actions or investments that are intended to meet goals and objectives directly or indirectly, to data about stress factors, exposure to stress, and condition or effects.

These elements apply to two different perspectives of "resource conservation." One is the anthropocentric, or utilitarian, view of what the EPA Science Advisory Board calls "sustainable flows", which evaluates the production and flow of products for human use, such as agricultural commodities, fish, lumber, recreational services, and the like. The other is the biocentric view of "sustainable states", which evaluates ecological health. Evaluations of sustainable states supply information about the inherent value of species,

habitats, and ecosystems. Measures and indicators related to sustainable states are more anticipatory and able to supply faster feedback on changes in relationships among system parts that affect future ecosystem and working landscape functions than sustainable flow measures. The Legacy Project will consider sustainable flow and sustainable state issues, since it is charged with providing information on both utilitarian and ecological attributes.

Figure A-1 depicts the relationships between goals (set by policy) and the scientific aspects influencing management decisions: landscape/ecosystem attributes, indicators, and measures. The pyramidal shape of the box on the right symbolizes the hierarchical nature of many specific monitoring data being transformed and aggregated into fewer indicators, and indicators being further aggregated into yet fewer landscape and ecological attributes.

Figure A-1. Conceptual Model of Feedback Loop between Science and Policy



The contents of the pyramid describe the scientific aspects of the assessment system, since attributes are a function of the ecosystem or the landscape. They can be objectively described to apply to aquatic and terrestrial ecosystems, working and recreational landscapes, and urban open space without attaching value judgments to them.

The box on the left is not a function of the landscape or ecosystem, but is an expression of societal preferences. Some of these are embedded in narrative or numeric goals in various legal mandates given to environmental stewardship agencies and local government. Although societal values expressed as conservation goals are independent of landscape attributes and monitoring data, they are strongly related and need to inform each other in a focused assessment and data integration program, such as proposed in this methodology.

Underlying most large-scale monitoring and assessment programs are variations of the internationally recognized Pressure-State-Response (PSR) model of environmental indicators, which is widely accepted for adaptive environmental management (OECD, 1993). According to this model, shown in Figure A-2, human activities and natural disturbances exert pressures or stress on fish and wildlife populations, communities, and ecosystems and thus influence their “state” or condition.

Adaptive management and conservation investment choices depend on a flow of scientific information from programs that monitor and assess the conditions of the system, the pressures or stress factors that might account for the observed states, the responses of management to the observed conditions (e.g., investing in restoration, stewardship, management practices reducing the sources of impact or stress), and the outcomes of the management responses. In theory, the outcomes of management responses, then, are expressed in an "improvement" of environmental condition, approaching or meeting a narrative or numeric resources conservation goal.

Figure A-2. Diagram of Pressure-State-Response Model

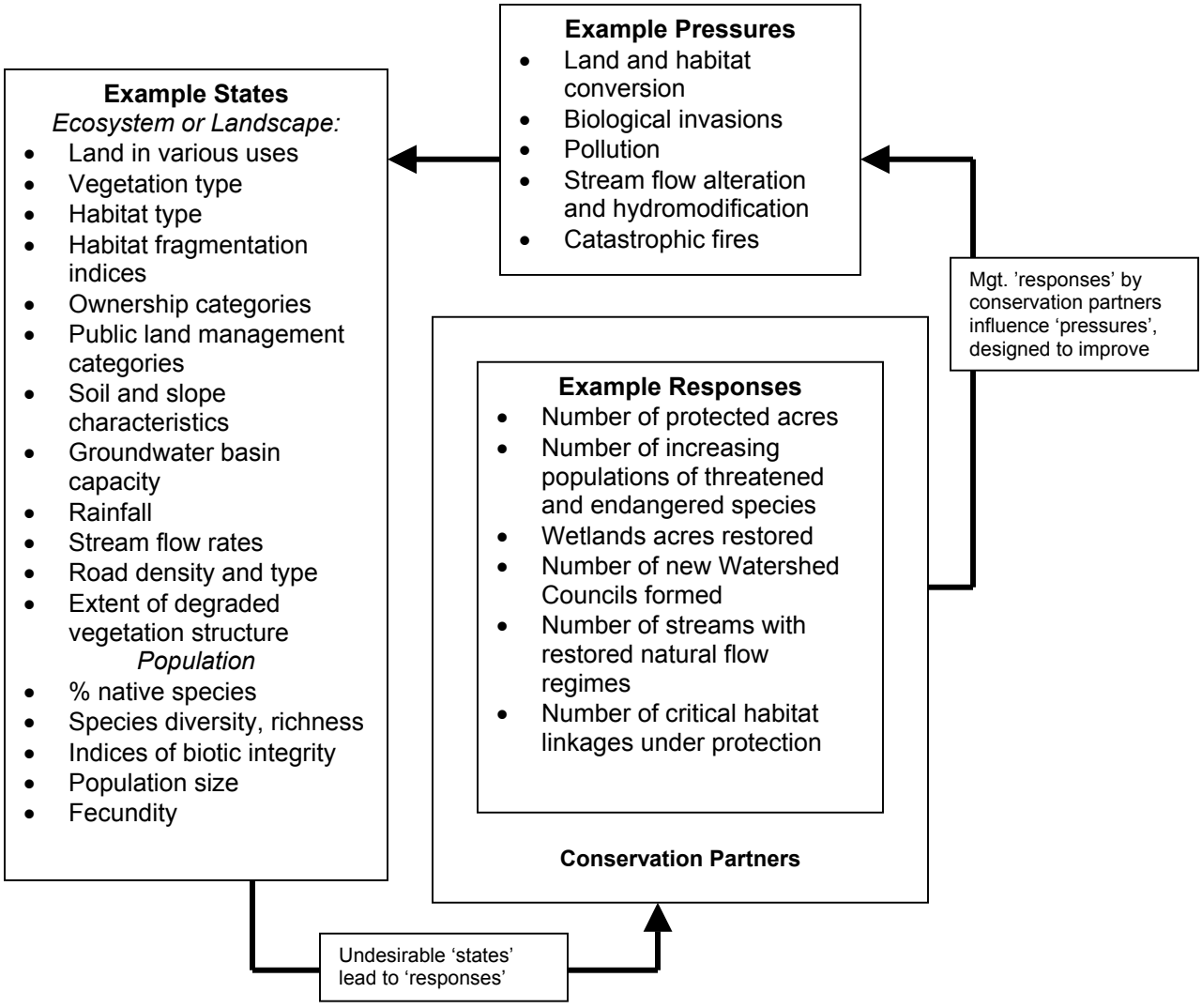
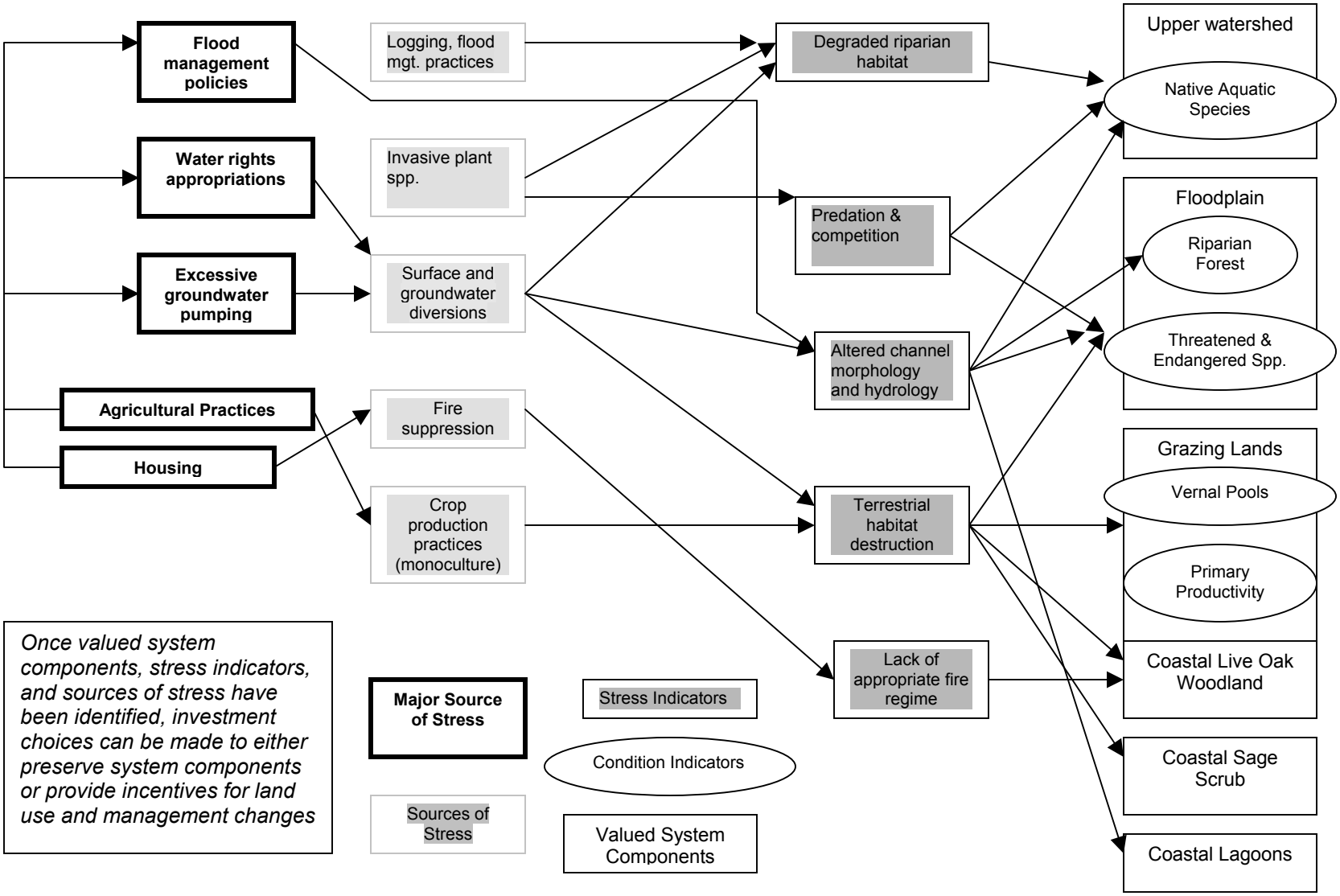


Figure A-3. Simplified Conceptual Model of Conservation Planning Strategies



APPENDIX B

Ongoing Monitoring Efforts[2] and Major Resource Assessment Programs

The various legislative mandates given to state agencies under the Public Resources, the Fish and Game, and the Water Codes can be summarized into broad goals that all relate to natural resource protection, land use, conservation, and restoration. This section describes how some of the data collection efforts by Resource Agency Departments and other state, federal, educational and nonprofit conservation partners may be grouped into categories defined by conservation goal statements. It also describes how more specific sub-groupings of data can then be compared with essential landscape and ecosystem attributes to answer questions about the health and condition of resources. The efforts put into the collection identified in this section do not represent an exhaustive list, nor does the list say much about how much progress has been made. The efforts listed will be a starting point for upcoming discussions with our partners to help implement the assessment methodology for the second RSAT report.[3]

A. Potential Condition Goals

The following goals were derived by synthesizing agency missions and the broad purposes of ongoing monitoring projects. They provide a useful framework to show relationships between current efforts and agency missions, but more discussion with state agencies is needed to confirm or modify these goals.

A.1 Maintain and restore natural diversity

Natural diversity can be characterized by both composition and structure elements and ecological function elements. Composition includes the types and variety of landscapes, habitats, species, or genetic variants. Structure is the physical organization of these features into patterns, such as fragmented landscapes, multi-storied forests or age distribution within populations. Ecological function elements involve ecological and evolutionary processes, such as natural fire cycles, predation, and gene flow, which are often more difficult to measure.

1.1 Composition and Structure Elements

1.1.1 Maintain natural patterns of habitat diversity

Changes in habitat diversity can be analyzed using repeated large-area habitat mapping, such as work by the USFS and CDF. Various indices of landscape patterns can be tracked over time, such as richness of habitats per unit area, dominance of habitats, habitat contrast, connectivity, and habitat fragmentation. More research is needed to identify the most meaningful indices.

---

[2] See end of this section for definition of agency/organization acronyms

[3] Sources:
DFG May 2001 informal survey of ongoing monitoring efforts, NDDB, WHR;
CDF-FRAP Assessment (table of contents for current draft) ;
Legacy data survey report, June 2001;
Agency websites

1.1.2 Maintain habitat quality

Assessing habitat quality statewide could be accomplished by using both disturbance indicators and sensitive species indicators. Readily available disturbance indicators on a statewide basis are road density or building density. Changes in those densities may be useful indicators of broad scale changes in habitat quality.

Sensitive species are typically called "sensitive" because their distribution and abundance typically respond to changes in habitat quality. Many agencies and organizations (DFG, CDF, CEC, CalFed; USFS, FWS, BLM, DOD, USGS; PRBO, Bighorn Institute, TNC, etc.) are monitoring sensitive species or their associated habitats throughout the state. The current activity status of each project still needs to be assessed. Although these efforts are asking a variety of monitoring questions, many of them will probably be valuable at least in identifying distribution, if not abundance, of specific species.

1.1.3 Maintain natural levels of native species diversity

As mentioned above, many agencies and organizations are monitoring native species, both sensitive and common, throughout the state. The current activity status of each project still needs to be assessed. Although these efforts are asking a variety of monitoring questions, many of them will probably be valuable at least in identifying distribution, if not abundance, of specific species.

1.1.4 Maintain natural levels of genetic variety within species

Monitoring genetic diversity is more difficult than monitoring species diversity. One approach is to track subspecies or populations of different species that survive under a variety of environmental conditions. Persistence at ecological extremes may indicate unique genetic variation. Examples of ecological extremes are the northern/southern most populations of a species, the highest/lowest altitudinal populations, or populations in the wettest/driest environment. Loss of these subspecies or populations could indicate loss of genetic diversity. Further work is needed to identify current monitoring efforts related to genetic diversity.

1.2 Ecological Function Elements

Ecological functioning is difficult to measure, even on a project-level basis. The following types of functions could be tracked through physical changes in habitat or species. Dramatic changes in these measurements from one time to another would highlight the need to examine the situation in more detail.

1.2.1 Natural fire dynamics

Fire dynamics can be measured by changes in fire history, intensity, and extent. Changes in the distribution and abundance of habitats or species that require regular wildfire may also indicate changes in fire dynamics. CDF is actively engaged in tracking this type of information.

1.2.2 Natural Hydrological dynamics

Changes in hydrological dynamics could be measured by changes in water impoundments, water diversions, and water supply. Several agencies (CDF, DFG, DWR, SWRCB, BLM, NPS, NRCS, and USEPA) are actively engaged in measuring these types of changes.

1.2.3 Soil Development and Retention

Changes in soil characteristics could be measured by sample point approaches, such as FIA or NRI, or can be derived from soils data of more extensive nature, such as NRCS soil mapping efforts.

1.2.4 Habitat Succession and Carbon Sequestration

Habitat succession is linked to carbon sequestration because older mature forests contain more carbon. Vegetation mapping as well as sample point data, such as FIA, is useful in measuring successional changes to habitats.

1.2.5 Predation

Tracking changes in the distribution or abundance of predator species (such as raptors, anadromous fish, and lions) may give an indication about changes in predator-prey interactions. Many agencies are engaged in tracking both common and sensitive predators, including DFG, CalFed, FWS, USFS, and BLM.

1.2.6 Migration/Dispersal

Tracking changes in the distribution or abundance of migratory species may give an indication about changes in migration dynamics. Landscape analysis of vegetation data can also indicate changes in habitat that may be important for migration and short-range dispersal. Migratory species are being tracked by DFG, CalFed, BLM, USFS, DOD, PRBO, TNC and many academic researchers.

2. Provide recreational opportunities - Wildlife Oriented Recreation

2.1 Access to lands and water

An important feature of wildlife-oriented recreation is public access to wildlands and waterbodies. A measure of changes in public access can be derived through an analysis of wildland vegetation, roads, lakes, streams, and public lands. The State Lands Commission identifies access to public trust lands and waters. Many State Conservancies track trails and access to natural and developed recreational areas. The DPR develops a state trails plan and tracks some access points to and between park units.

2.1.1 Habitats and Species of Recreation Interest

Wildlife-oriented recreation depends on changes in the distribution and abundance of key habitats and species that have high recreational interest. In addition to the habitat mapping efforts mentioned above, species of recreational interest are being tracked by CDF, USFS, BLM, DOD, FWS, USGS, LAWP, Bighorn Institute, California Waterfowl Association, Ducks Unlimited, and Bear League.

2.2 Open-space Oriented Recreation

2.2.1 Access to water, coast, and wooded lands

An important feature of open space-oriented recreation is public access to wildlands of high recreational value. A measure of changes in public access can be derived through an analysis of wildland vegetation, roads, lakes, streams, and recreational facilities (picnic and campgrounds), and public lands. Changes in visitor use rates on public lands, tracked by DPR, USFS, and BLM, may be useful measures also.

2.2.2 Maintain viewsheds

Changes in viewsheds could be tracked through a 3-D spatial analysis of topography, roads, vegetation, water bodies, public lands, and recreational facilities (picnic and campgrounds)

3. Maintain and improve water quality

Water quality can be monitored through physical and chemical measures as well as biological responses, such as fish or invertebrate populations. Agencies active in this area include SWRCB, DFG, CALFED, USEPA, USFS, and BLM. Many nonprofit agencies also focus on measuring fresh and ocean water quality.

4. Maintain sustainable working landscapes

Goals for working landscapes include many of the above goals. In addition, each type of working landscape may have their own unique set of goals, such as the following examples. Not all goals may apply to all areas, depending on specific management goals. However, on a statewide basis, these are goals that could be measured using existing monitoring/assessment efforts.

4.1 Productive farmlands

4.1.1 Maintain crop productivity/yield

USDA California Agricultural Statistics Service works cooperatively with the California Department of Food and Agriculture (CDFA), County Agricultural Commissioners' Offices and Agri-Industry representatives in tracking county level estimates of various crops, including grain and hay stocks, wheat, rice, field crop prices, cotton, potatoes, fruits and nuts .

4.1.2 Maintain acreage of productive farmlands

DOC's Farmland Mapping and Monitoring Program regularly update maps and statistical data describing the distribution and abundance of productive farmlands.

4.2 Productive forestlands

4.2.1 Maintain timber species diversity and productivity

CDF's Forest and Fire Assessment Program, in conjunction with USFS, regularly assess the diversity of timber species, their distribution and abundance, and timber productivity rates.

4.3 Productive grazing lands

4.3.1 Maintain livestock productivity/yield

USDA California Agricultural Statistics Service and CDFA, as mentioned above also track county level estimates of cattle and sheep productivity.

4.3.2 Maintain adequate forage cover (yield and digestibility)

Livestock forage cover can be measured by the distribution and abundance of vegetation types preferred by livestock. In addition to the vegetation mapping efforts described above, USFS, BLM and CDF assess the quality of livestock forage.

B. Stressors

These stressors describe a variety of influences that tend to change the current condition of natural diversity. These are grouped by major land use/ecosystem below, because different types of lands and ecosystems (and the species within them) experience different types of pressures.

B.1 Accelerated Soil Erosion

Soil erosion can be measured by site sampling, such as NRCS's NRI or USFS's FIA. Changes to soil or vegetation, particularly in areas of highly erodible soils, can also provide indication of increases in soil erosion. Agencies tracking this type of information include CDF, USFS, and NRCS. Changes in downstream water quality (see above) may also provide useful indicators of increased soil erosion.

B.2 Expanded ranges of non-native invasive plants and animals

Several agencies have initiated efforts to track invasive species, including DPR, CalFed, CDFA, DFG, and CDF.

B.3 Land conversion

Land conversion implies different types of stress, depending on the existing land cover and the extent and intensity of conversion. The general pattern in California is a conversion from wildlands to working landscapes (managed forests, rangeland or crop land) to rural residential or urban use. Agencies involved in vegetation mapping (DFG, CDF, DOC, DWR, USFS, NRCS, AND BUREC) are also involved in land cover mapping and their efforts can be used to track land conversion over time.

B.4 Increased Human Access to Sensitive Areas

Increased human access can introduce additional stress on natural systems. Increased risk of wildfires and accelerated erosion from unmanaged roads are some of the stresses. Human activity during certain seasons can disturb sensitive species breeding and wintering activities. Increases in the density of roads, or the changes in the types of roads, particularly in sensitive areas, can be used as an indication of increased human activity.

B.5 Changes in Water Diversions and Impoundments

Several agencies (Caltrans, DWR, USGS, COE) inventory a variety of water diversions, fish passage obstacles, and water impoundments. These stresses affect fish movement and can alter habitats downstream.

B.6 Increased non-point source pollution

Non-point source pollution is changes in water quality that can not be attributed to a specific point, such as an outfall pipe from a single industrial site. Non-point source pollution includes changes in sediment loads and turbidity as well as contamination of sediments, water acidification, high levels of nitrates, metals, chemicals, bacteria and other pathogens.. SWRCB, USEPA, major metropolitan areas and industrial, public works agencies, and agricultural uses all report monitoring data to RWQCBs through the NPDES permitting process and USGS's NAWQA program all monitor various aspects of water quality and nonpoint source pollution.

B.7 Changes in tree pathogen (insects, fungi) distribution and abundance

Tree pathogens, such as pitch canker or sudden oak death, as well as other insect/fungi outbreaks, are tracked by CDF and USFS.

B.8 Changes to Crop pathogens (insects, fungi) distribution and abundance

Crop pathogen, or pest, outbreaks are tracked by the Department of Pesticide Regulation and the University of California Statewide Integrated Pest Management Project as well as the California Department of Food and Agriculture.

B.9 Loss of viewshed (air quality, adjacent land-uses)

Changes in viewsheds could be tracked through a 3-D spatial analysis of topography, roads, vegetation, water bodies, public lands, and recreational facilities (picnic and campgrounds) Air quality monitoring by air quality management districts throughout the state measure visibility.

C. Management Outcomes

Agencies and organizations are taking a wide range of actions to respond to changes, whether existing or expected, in the condition of natural diversity. Listed below are examples of those responses that could be measured quantitatively over time to illustrate progress in conservation.

C.1 Increased collaborative natural resource planning

Collaborative natural resource plans include regional conservation plans (NCCPs, HCPs) and watershed plans (including setting standards for TMDLs and CRMPs). DFG, FWS, and the UC Davis Natural Resources Project Inventory track the location of these plans.

C.2 Improvements to long-term conservation status

Land can receive longer term assurances of conservation status through acquisition efforts on private lands (both fee-title and easements) and special land-use designation on public lands. Many federal, state, nonprofit land trusts, park district and local government land-managing agencies track these newly acquired or designated lands.

C.3 Restoration of degraded or lost habitats

Restoration projects are tracked by UC Davis Natural Resources Project Inventory. Funding for restoration can be analyzed by examining individual agency and organization expenditures

Agency and Organization Acronyms

BLM	Bureau of Land Management
BUREC	Bureau of Reclamation
CALFED	CalFed Bay-Delta Program
CDF	California Department of Forestry and Fire Protection - Fire and Resource Assessment Program
CEC	California Energy Commission
COE	US Army - Corps of Engineers
Dept PestReg	California Department of Pesticide Regulation
DFG	California Department of Fish and Game
DOC	California Department of Conservation
DOD	US Department of Defense
DPR	California Department of Parks and Recreation
DU	Ducks Unlimited
DWR	California Department of Water Resources
FEMA	Federal Emergency Management Agency
FIA	USFS Forest Inventory and Analysis Program
FWS	US Fish and Wildlife Service
ICE	UC Davis - Information Center for the Environment
LADWP	Los Angeles Department of Water and Power
NAWQA	USGS National Aquatic and Water Quality Assessment
NDDB	DFG Natural Diversity Data Base
NPDES	USEPA National Pollutant Discharge Elimination System
NPS	US National Park Service
NRCS	USDA - Natural Resources Conservation Service
NRI	USDA - NRCS - Natural Resources Inventory
PRBO	Point Reyes Bird Observatory
SWRCB	California State Water Resources Control Board
TNC	The Nature Conservancy
UCD	UC Davis
UCD ICE	University of California at Davis Information Center for the Environment
USEPA	US Environmental Protection Agency
USFS	US Forest Service
USGS	US Geological Survey